

**TITLE OF THE INVENTION**

**DIGITAL IMAGE PROCESSING APPARATUS**

5           This application is based on application No.  
H10-115868 filed in Japan, the contents of which are  
hereby incorporated by reference.

**BACKGROUND OF THE INVENTION**

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**1. Field of the Invention**

          This invention relates to the field of digital  
image processing.

15           **2. Description of the Related Arts**

          Digital image processing techniques have major  
features of easy image editing and modifications.

          Figs. 16, 17, and 18 are conceptual diagrams  
showing the configuration of such prior art image  
20       automatic correction software.

          Usually an editor (operator) performs various  
operations on an original image with the aid of such  
software, thereby obtaining a desired image in a trial  
and error fashion.

In such a process, an image at each step in which an original image is subjected to different processing as shown in Fig. 17 is saved, and if a desired image is not obtained by processing in one way, processing is often performed again from the beginning or performed on an intermediate image in a different way.

In the process of the operations, carefully making records of an original image pertaining to image data created at each step, information about processing on the images, and other information may avoid confusion, but an editor often concentrates attention to processing itself and neglects such recording, so that data at intermediate steps is disorderly accumulated, with the result that the intermediate data cannot be reused. For this reason, operations that have been heretofore performed often become meaningless.

In the case where a plurality of images are processed at a time as in automatic image correction software as shown in Fig. 18, the same problem as described above occurs since it cannot be determined what processing the program performed on each image.

Furthermore, also when image data is passed to different editors, the editors will perform similar

operations because the history of the image data is not always clear.

Although an image produced as a result of image processing may be intuitively different from an original image thereof, it cannot be practically determined visually what processing has been performed to produce the image, what the original image was like, which of two pieces of data, if any, is the original image, and the like.

Presently, numerous file formats of images are proposed and some of them permit predetermined information to be written in advance in a predetermined area (tag) of a file. However, some file formats do not have such an area or have no area corresponding to information to be written; these formats are inconvenient to use because desired information cannot be recorded.

The United States Patent No. 5,530,759 by Gordon et al discloses a system for placing a visible "watermark" on a digital image, wherein an image of the watermark is combined with the digital image.

The pixels of the watermark image are examined, and for each pixel whose value is not a specified "transparent" value, the corresponding pixel of the

original image is modified by changing its brightness but its chromaticities. This results in a visible mark which allows the contents of image to be viewed clearly, but which discourages unauthorized use of the image.

5           The important matter of this patent is that the contents of image are visible and thereby the unauthorized use of the image is prevented.

#### SUMMARY OF THE INVENTION

10           An object of this invention, which is different from that of the Gordon's patent, is to solve the problem described above by arresting the recognition of written information by users, that is, reducing to a minimum a visible influence on images, and nevertheless  
15 by making it possible to determine what processing was performed on image data or when the processing was performed, from information of the image data itself.

          In this invention, bits for describing information different from information of processed  
20 image data, obtained by image processing on original image data, are placed respectively in specific bit positions of pixel data at predetermined positions of the processed image. The specific bit positions are placed dispersively over the image surface and thereby

information different from image information can be embedded in the image information without substantially influencing the quality of image.

According to this invention, the history of  
5 image processing on digital images can be saved in image data itself.

In the case where a plurality of images are processed at a time as in automatic image correction software, it cannot be determined with the prior art  
10 what processing the program performed on each piece of image data. However, according to this invention, information about the processing can be saved as a record.

Since the history of processing is recorded in  
15 image data itself according to this invention, an original image can be restored by reversing the processing.

Even if there are a number of similar images, according to this invention, the oldest image or an  
20 original image can be easily recognized from the history of processing.

According to this invention, since any information can be recorded, a picture date and names can be recorded and saved so that they are hidden from

view.

According to this invention, since information can also be cryptographically recorded, although processing is heavily loaded, secret information can be  
5 thereby recorded.

According to this invention, since information is embedded in image data itself, different types of information can be recorded regardless of the formats of image files.

10 Other objects and advantages besides those discussed above shall be apparent to those skilled in the art from the description of a preferred embodiment of the invention which follows. In the description, reference is made to accompanying drawings, which form  
15 a part thereof, and which illustrate an example of the invention. Such example, however, is not exhaustive of various embodiments of the invention, and therefore reference is made to the claims which follow the description for determining the scope of the invention.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention

and together with the description, serve to explain the principles of the invention.

Fig. 1 is a flowchart for explaining the outline of this invention.

5 Fig. 2 is a subroutine flowchart showing the contents of a subroutine "Writing processing records" in Fig. 1.

10 Fig. 3 is a table showing the correspondences between image processing contents and code numbers representing them.

Fig. 4 is a diagram showing information embedded in image data - in this example, processing information, date information, and version information.

15 Fig. 5 is a table representing the image positions of pixels in which processing information is embedded.

Fig. 6 is a diagram for explaining an operation to set the least significant bit of pixel data to 0.

20 Fig. 7 is a diagram for explaining the principle to embed processing information in the least significant bit of pixel data, which was set to 0 in Fig. 6.

Fig. 8 is a table showing, with respect to an R plane, the positions of pixels to which processing

information is written in a second embodiment.

Fig. 9 is a table showing, with respect to a G plane. the positions of pixels to which processing information is written in a second embodiment.

5 Fig. 10 is a table showing, with respect to a B plane. the positions of pixels to which processing information is written in a second embodiment.

10 Fig. 11 is a table showing, with respect to an R plane. the positions of pixels to which processing information is written in a third embodiment.

Fig. 12 is a table showing, with respect to a G plane. the positions of pixels to which processing information is written in a third embodiment.

15 Fig. 13 is a table showing, with respect to a B plane. the positions of pixels to which processing information is written in a third embodiment.

Fig. 14 is a system diagram for explaining the outline of this invention.

20 Fig. 15 is a diagram showing an internal configuration of a computer.

Fig. 16 is a conceptual diagram showing the configuration of prior art image automatic correction software.

Fig. 17 is a diagram for explaining the flow of



operations of prior art software that edits and processes a full color image on a personal computer.

Fig. 18 is a diagram for explaining the flow of prior art software that processes a plurality of images at a time.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 14 is a system diagram for explaining the outline of this invention. To a computer 10, a display 11 is connected. Furthermore, a keyboard 12 and mouse 13 used for input are connected to the computer 10. The computer 10 has a front-mounted FD unit 107 for reading from and writing to a recording medium (flexible disk) 20. On the other hand, a printer for providing output from the computer 10 is connected via network N.

Fig. 15 is a block diagram showing an internal configuration of the computer.

In the interior of the computer 10, CPU 101, ROM 102, RAM 103, input-output port 104, keyboard 105, mouse 106, FD unit 107, and HD (hard disk) unit are connected via a bus 100.

The computer 10 singly or jointly executes a program stored in the ROM 102, and a program stored in the RAM 103, supplied from the flexible disk 20 or the

network N. Image data to be edited is stored in the RAM  
103 or HD unit 108.

#### First embodiment

Fig. 1 is a flowchart for explaining the outline  
5 of this invention. This invention is provided with a  
subroutine "Writing processing records" as shown in the  
figure.

In this subroutine, necessary data is embedded  
in image data without substantially influencing the  
10 image. This method will be described later. The  
flowchart of Fig. 1 will be described.

This program, when started (step S1), in step S2,  
selects an image to be subjected to image processing.  
In step S3, the program edits and processes the  
15 selected image. The contents of the image processing  
vary depending on purposes. The program displays the  
processed image on a display unit (step S4), checks to  
see if it is as intended, proceeds to the subroutine  
"Writing processing records" (step S5), and writes a  
20 record of the contents of the performed image  
processing to image data. The program saves the image  
data to which processing contents are written (step S6),  
and terminates in step S7.

Fig. 2 is a subroutine flowchart showing the

contents of the subroutine "Writing processing records"  
(step S5).

The subroutine "Writing processing records",  
when started (step S11), transfers the contents of  
5 image memory to a work memory. The subroutine performs  
bit packing on write data in step S13. The bit packing  
is performed as described below.

The contents of image processing are assigned  
code numbers that can be represented in one byte, as  
10 shown in the table of Fig. 3. For example, if the  
contents of image processing are contrast correction by  
method 2, a code of 22 in hexadecimal notation is  
assigned.

Date is represented by elapsed time, in minutes,  
15 from 0:0 a.m., January 1, 1998. For this reason, 32  
bits are used. Four-bit data is provided to check the  
version of processing history.

These information items are as shown in Fig. 4  
when sequentially arranged. A is a portion indicating  
20 the contents of image processing, B is a portion  
indicating date, C is a portion indicating version  
check information, and b is a bit making up these items.

These bits are placed dispersively over the  
surface of an image subjected to image processing. The

positions in which they are placed are calculated in step S14.

An image used in this example is a full-color natural image the size of which is 1280 by 1024 pixels.

5 The positions of the 44 bits in the image are decided. The bits are embedded as described below with respect to each of the R, G, and B planes of the image.

10 The image is divided by 8 both in the horizontal and vertical directions into 64 ( $8 \times 8$ ) units, values with a fractional portion truncated. The central pixel both in the horizontal and vertical directions of each unit is used to embed information, and bit positions are decided as shown in the table of Fig. 5.

15 In each position, the 44-bit information is embedded in the least significant bit (LSB) positions of intensity data of each pixel.

Since a pixel position in which each of the 44 bits is placed is decided in this way, the subroutine proceeds to step S15.

20 In this step, the pixel data at the each position of the image is modified as follows.

Data of each pixel, which is one byte, assumes any hexadecimal value from 00 to FF. As a result of the logical AND operation of the data with the hexadecimal

value FE, pixel data with only the least significant bit set to 0 is obtained (Fig. 6).

As a result of the logical OR operation of bits of the above packed data and pixel data with the least  
5 significant bit set to 0, pixel data with necessary data embedded will be obtained (Fig. 7).

The subroutine transfers the obtained data to the image memory (step S16) and exits in step S17.

Since processing information is written  
10 dispersively in this way and only the least significant bit of image data changes, there is no substantial reduction in image quality.

#### Second embodiment

15 In the above-mentioned embodiment (first embodiment), an image is manipulated in the same way for each plane of R, G, and B colors. Consequently, the processing information may be visible on faint images. In a second embodiment, this drawback is eliminated by  
20 making the processing information more inconspicuous.

Figs. 8, 9, and 10 are tables showing the positions of pixels to which processing information is written, with respect to R, G, and B planes.

As shown in the tables, the positions of pixels

in which processing information is embedded are reversely shifted five pixels relative to the R plane, in the case of the G and B planes.

By this arrangement, processing information is  
5 embedded more dispersively, making the existence of the processing information more inconspicuous.

Even in an image to which no processing  
information is written, pixel data at the above-  
mentioned positions may happen to be arranged  
10 meaningfully. At this time, the pixel data may be read mistakenly as information. In this embodiment,  
identical information is written to each of the R, G,  
and B planes. During reading of the information, by  
checking whether these information pieces match, such  
15 an accident can be eliminated.

#### Third embodiment

The second embodiment provides for the case  
where given information is visible as noise. However,  
20 since the 44 bits may accidentally form a meaningful data array, in the third embodiment, as shown in Figs.  
11, 12, and 13, five bits are added as parity data to  
make 49-bit configuration.

#### Fourth embodiment

In the embodiments that have been heretofore described, the positions of pixels to embed processing information in are fixed. In this embodiment, several  
5 patterns of these positions are provided, and a pattern can be selected from these patterns so that influence on the image is minimized.

Although the least significant bit of image data  
10 is modified in the above-mentioned first to fourth embodiments, other than the least significant bit may be modified if the modification is inconspicuous. For example, if the range of intensity of image is wide (e.g., 16 bits), the second or third bit position from  
15 the least significant bit position may be modified. Also, if resolution is high, a higher bit position may be modified because modification of a single pixel is inconspicuous.

As seen in these embodiments, since information  
20 is embedded in image data itself, various information can be recorded regardless of the formats of image files.

Although only preferred embodiments are specifically illustrated and described herein, it will

be appreciated that many modifications and variations  
of the present invention are possible in light of the  
above teachings and within the purview of the appended  
claims without departing from the spirit and intended  
5 scope of the invention.

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